# Progress Report on the Effects of Nutrition, Bruising, and Washing Upon Rotting of Stored Sugar Beets[1]

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Rotting of stored sugar beets, *Beta vulgaris* L., is a problem of major importance in the sugar beet industry in the United States. Rotting is caused by microorganisms which are greatly influenced by various conditions of storage as well as by the nature and condition of the beet roots stored. The role of certain of these factors, in relation to severity of rot losses, has been discussed by Tompkins and Nuckols (5)[3], Larmer (4), Gaskill (1, 2, 3), and by other investigators.

This paper, based on one year's results, is presented merely as a progress report on certain studies initiated at Fort Collins, Colorado, in 1948. Samples of topped sugar beet roots were stored in two insulated rooms under controlled conditions described by the author in another article (2). At the end of storage, the proportion of rot in each sample was determined by separating and weighing the rotted and healthy tissue.

## Nutrition

In the spring of 1948 a field near Fort Collins, Colorado, which had produced a low yield of sugar beets in 1947 and which was thought to be relatively low in general fertility was chosen for use in studying effects of nutrition upon keeping quality. The inorganic fertilizers, ammonium nitrate, treble superphosphate, and muriate of potash, were applied on the surface before plowing in April, with rates and combinations as outlined in Table 1. The 18 fertilizer treatments were placed in the field in equalized random blocks, with 3 replications, and subdivided by strips of 3 varieties in random arrangement. Individual plots were 4 rows x 40 feet; rows 20 inches apart. Border effects of fertilizer treatments were eliminated by suitable buffer strips and harvest alleys.

Harvest yields and sucrose data were obtained as a means of evaluating the deficiencies of the 3 nutrients under study. Root yield was determined for each plot from the washed weight of all roots in 36 feet of row, and sucrose percentage was obtained from one 20-beet sample per plot. Response to potash fertilizer was negligible. Phosphate fertilizer did not affect svicrose percentage significantly, but the average acre yield of roots for the heaviest application was 1.24 tons above that of the unphosphated plots—a

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[3] Numbers in parentheses refer to literature cited.

**Table 1.—Fertilizer applications in replicated field plots, Fort Collins, Colorado, 1948.**

| Pounds[1] $K_2O$ per Acre | Pounds[1] $P_2O_5$ per Acre | Pounds N applied per acre and treatment No.[2] | | |
|---|---|---|---|---|
| | | 0 | 50 | 150 |
| 0 | 0 | 1 | 2 | 3 |
| | 100 | 4 | 5 | 6 |
| | 300 | 7 | 8 | 9 |
| 50 | 0 | 10 | 11 | 12 |
| | 100 | 13 | 14 | 15 |
| | 300 | 16 | 17 | 18 |

[1] Fertilizers used:
N—Ammonium nitrate.
$P_2O_5$—Treble superphosphate.
$K_2O$—Muriate of potash.

significant difference. Response to nitrogen was much more pronounced and highly significant, with average root yields of 9.07, 10.80, and 12.44 tons per acre and average sucrose percentages of 16.59, 16.55, and 15.92, respectively, for 0, 50, and 150-pound applications of nitrogen per acre.

One sample of 20 washed roots from each of the 162 field plots was stored at 65° F. for approximately 3 months, and a duplicate set of samples was held at 45° F. for about $4^{1/2}$ months. Summarized rot percentages at the end of storage are shown in Tables 2 and 3. Since interactions between varieties and fertilizer treatments were not significant, the data for the 3 varieties were pooled. Interactions between nitrogen, phosphorus and potassium were not computed and were disregarded. From the summarized data it appears that none of the 3 nutrient elements influenced materially development of storage rot, except for nitrogen effects under 45° storage. In that room, the average percentage of rot for the 150-pound nitrogen application was less than half the percentage obtained for plots receiving no nitrogen—a highly significant difference. Percentage rot for the 50-pound rate was intermediate and was significantly below that obtained for the zero application.

The beneficial effect of nitrogen upon keeping quality in. this experiment, under 45° conditions, is in agreement with results reported by Larmer (4) for roots taken from fertilized and unfertilized plots in a field which he classed as extremely low in fertility. Failure of phosphate and potash fertilization to improve keeping quality need not be considered as contradictory of Larmer's results since those fertilizers produced relatively little root-yield response in the Fort Collins field.

## Bruising and Washing

Mechanical injury opens the way for invasion of sugar beet roots by certain kinds of microorganisms, classed as wound parasites, which do not readily penetrate the unbroken periderm. In the process of harvesting, hauling, and piling of sugar beets a certain amount of bruising and gouging is inevitable, and with certain types of mechanical harvesters there is a tendency toward a greater amount of injury than occurs with moderately careful hand topping.

Table 2.—Effects of field fertilization upon development of rot in sugar beet roots during approximately 3 months' storage at 65° F.; results shown as 9-plot averages for each of 18 fertilizer treatments. Fort Collins, Colorado, 1948-49.

| $K_2O$ per acre | $P_2O_5$ per acre | Pounds N per acre and weight of rotted tissue 0 | 50 | 150 | Average wt. of rotted tissue | | Average for $P_2O_5$ $P_2O_5$ per acre | Wt. of rotted tissue |
|---|---|---|---|---|---|---|---|---|
| Lbs. | Lbs. | Percent | Percent | Percent | Percent | Percent | Lbs. | Percent |
| 0 | 0 | 29.2 | 32.2 | 36.4 | 32.6) | | | |
| | 100 | 31.3 | 33.8 | 28.6 | 31.2) | 31.1 | | |
| | 300 | 28.5 | 40.2 | 19.9 | 29.5) | | 0 | 32.6 |
| | | | | | | | 100 | 32.3 |
| | | | | | | | 300 | 32.5 |
| 50 | 0 | 36.8 | 26.3 | 34.5 | 32.5) | | | |
| | 100 | 28.4 | 40.5 | 31.4 | 33.4) | 33.8 | | |
| | 300 | 35.5 | 36.3 | 34.3 | 35.4) | | | |
| Average | | 31.6 | 34.9 | 30.9 | | | | |
| L. S. D.[1] | | | 5.6 | | | 4.6 | | 5.6 |

[1] Least significant difference (5-percent point) applicable to general averages.

In the fall of 1948 an experiment was designed for the purpose of studying the effects of bruising and, in addition, to furnish information regarding the influence of washing upon keeping quality. The latter factor was included partly because of possible commercial applicability and partly because washed roots were being used in various other storage-rot experiments at the Fort Collins station. Twenty-four comparable 20-beet samples of a commercial variety were divided into 4 lots of 6 samples each which were treated as follows:

(1) Washed, dried, uninjured.
(2) Washed, dried, bruised.
(3) Unwashed, uninjured (approximately 1.7 percent adhering soil).
(4) Unwashed, bruised (approximately 1.3 percent adhering soil after bruising).

Table 3.—Effects of field fertilization upon rotting of sugar beets during approximately $4^{1/2}$ months' storage at 45° F.; results given as 9-plot averages for each of 18 fertilizer treatments. Fort Collins, Colorado, 1948-49.

| $K_2O$ per acre | $P_2O_5$ per acre | Pounds N per acre and weight of rotted tissue 0 | 50 | 150 | Average wt. of rotted tissue | | Average for $P_2O_5$ $P_2O_5$ per acre | Wt. of rotted tissue |
|---|---|---|---|---|---|---|---|---|
| Lbs. | Lbs. | Percent | Percent | Percent | Percent | Percent | Lbs. | Percent |
| 0 | 0 | 6.8 | 7.1 | 4.0 | 6.0) | | | |
| | 100 | 9.6 | 5.7 | 8.3 | 7.9) | 7.0 | | |
| | 300 | 8.4 | 11.4 | 1.9 | 7.2) | | 0 | 6.6 |
| | | | | | | | 100 | 7.6 |
| | | | | | | | 300 | 6.9 |
| 50 | 0 | 13.5 | 3.1 | 4.9 | 7.2) | | | |
| | 100 | 10.0 | 8.3 | 3.4 | 7.2) | 7.0 | | |
| | 300 | 10.8 | 5.6 | 3.0 | 6.5) | | | |
| Average | | 9.9 | 6.9 | 4.3 | | | | |
| L. S. D.[1] | | | 2.7 | | | 2.2 | | 2.7 |

[1] Least significant difference (5-percent point) applicable to general averages.

The bruising treatment consisted of allowing the beets to tumble 3 times down a board slide 8 feet long, set at a 45° angle from the vertical, and having a 34-inch wood cleat across the upper surface about half way down and another near the bottom. The roots were caught in a box about 1 foot deep set beneath the lower end of the slide. Aside from the breaking of the tips of some tap roots, injuries produced were of *2* kinds, namely:

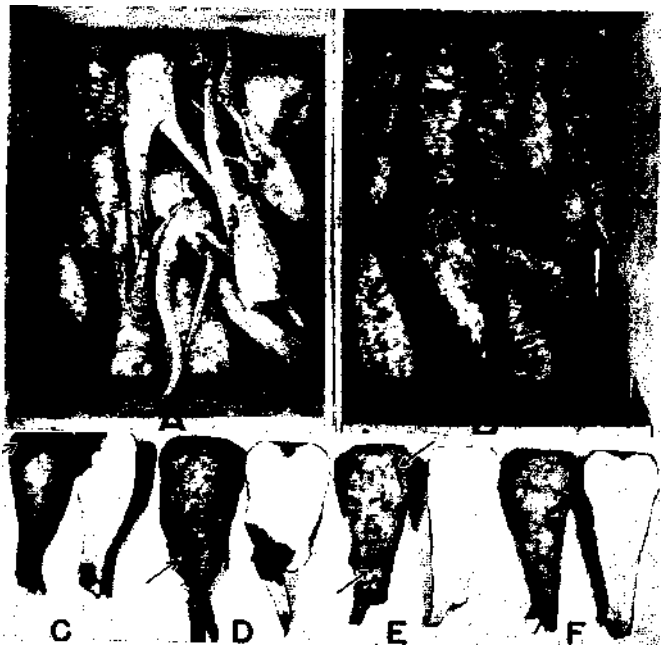


**Figure 1. Effects of bruising upon keeping quality of washed sugar beet roots. Top—beet samples after storage for 78 days at 65° F.: A, sound; B, bruised. Bottom—4 roots after 119 days' storage at 45° F.: C, D, and E were bruised, arrows indicating severely injured areas, some of which apparently served as openings for initial fungous invasion; F, not bruised.**

(1) light scuffing of small areas and (2) deeper bruises or gouged areas, principally those caused by beets striking the cleats on the slide. After treatment each of the 4 groups of samples was divided between the 2 storage rooms.

After 82 days' storage at 65° and 125 days at 45°, the percentage rot in each sample was determined in the usual way, adhering soil disregarded. The results (Table 4) indicate relatively little influence of washing upon percentage rot and negligible interaction between washing and bruising.

Tabic 4.—Storage rot of sugar beets as affected by bruising and washing; basic data presented as averages of three 20-beet samples. Fort Collins, Colorado, 1948-49.

| Treatment | Weight of rotted tissue at end of storage | | | | |
|---|---|---|---|---|---|
| | Washed | Dirty | Average | Difference | L. S. D.[1] |
| | Percent | Percent | Percent | Percent | Percent |
| | | 65° F. storage, 82 days | | | |
| Bruised | 26.1 | 32.9 | 29.5) | 16.9 | 12.8 |
| Sound | 13.7 | 11.5 | 12.0) | | |
| Average | 19.9 | 22.2 | | | |
| Difference | 23 | | | | |
| L. S. D.[1] | 12.8 | | | | |
| | | 45° F. storage, 125 days | | | |
| Bruised | 5.3 | 6.3 | 5.8) | 1.9 | 3.2 |
| Sound | 2,9 | 4.9 | 3.9) | | |
| Average | 4.1 | 5.6 | | | |
| Difference | 1.5 | | | | |
| L. S. D.[1] | 3.2 | | | | |

[1] Least significant difference (5-percent point) applicable only to differences shown—i.e., differences between means of 6 samples. Interaction between washing and bruising treatments was negligible.

Rotting was more severe among the bruised roots at both storage temperatures, the difference being significant in the warmer room. As illustrated in Figure 1, there was a tendency for severely bruised or gouged areas to serve as pathways for fungous invasion, whereas mild bruising or scuffing seemed to have little effect.

## Summary

Samples of topped sugar beets were stored at approximately 05° F. and 45° F. for about 3 months and 4 to $4^{1/2}$ months, respectively, and the percentage of rot in each sample was determined at the end of storage by separating and weighing the rotted and healthy tissue.

Beet roots grown in replicated nitrogen-fertilized plots in a field moderately deficient in nitrogen kept significantly better in 45° storage than roots from comparable plots receiving no nitrogen. At 05° there were no significant differences attributable to nitrogen. Effects of potash and phosphate fertilizers on keeping quality were negligible in this experiment at both temperatures. This was not surprising in view of the fact that harvest data showed negligible yield response to potash fertilization and relatively little such response to phosphate.

Results from a replicated experiment pertaining to the effects of washing and bruising upon keeping quality showed a higher percentage of rot for injured roots than for sound ones at both storage temperatures. At 65° the difference was significant. Washed roots kept only slightly better than unwashed roots, the differences being far from significant.

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